

circumstances such as contamination with industrial by-products. For the purpose of boiler feed the important points to be decided in connection with a natural water are the presence or absence of corrosive substances and the extent to which on evaporation it gives rise to hard incrustations, the so-called boiler scale. The probable character of these deposits is also a matter of interest in the choice of a water-supply for steam-raising.

ANALYSES OF NATURAL WATERS IN
GRAINS PER GALLON

	Glasgo w.	Londo n.	Stoke- on- Trent.	Lincol n.	Ha wick.	Colliery Feed- water.	Colliery Feed- water.
Dissolved solids	2.94	S-ii	4.9	27.9	24.3	33.9	77.8
Mineral matter	1.75	3.78	4.7	22.0	22.0	31.3	76.9
Organic matter	1.19	1.33	0.2	5.9	2.3	2.6	0.9
Chlorine	0.65	0.40	0.9	2.8	1.1	1.5	1.9
Temporary	0.44	2.48	2.0	8.1	11.0	—	29.4*
Permanent	0.18	0.53	0.7	8.7	6.7	—	—
Acidity as H ₂ SO ₄	—	—	—	—	—	2.9	—

* Alkalinity: the water contains sulphate and carbonate of soda.
Sea-water contains about 2300 gr. of solid matter per gallon.

Hardness.—The bicarbonates of lime and magnesia render water alkaline to indicators such as methyl orange or alizarin paste, and more or less mineral acid is required to make waters which contain these bodies once again neutral. If the amount of acid required per gallon to effect neutrality in the water be expressed in terms of grains of carbonate of lime needed to combine with it, the figure obtained is called the temporary hardness. The temporary hardness is thus the alkalinity of the water expressed in grains of carbonate of lime per gallon. One degree of hardness is the equivalent of one grain of carbonate of lime per gallon. The bicarbonates of lime and magnesia are unstable in the heat and separate the respective carbonates when the water is boiled, and these, being much less soluble, are almost entirely precipitated. Hence the alkalinity or temporary hardness of a water as determined represents approximately the lime and magnesia thrown out as carbonates on heating the water. Deep-well and pit waters sometimes contain alkalinity due to carbonate of soda

and not removed on boiling the water.

Water that contains lime and magnesia in the more stable forms of sulphates, chlorides, and nitrates does not part with these on boiling. On the other hand, if alkali be added to such a water, the bases forming these salts are precipitated, more or less alkali being used up in the process, and the amount so used up can be determined by an acid test. In this way it is possible to determine the alkali-destroying power of these substances in a gallon of the water and to express this in terms of their equivalent of carbonate of lime. The figure so obtained is the permanent hardness. The permanent hardness